

Global Changes in the Atmosphere

Reading Preview

Key Concepts

- What events can cause short-term climate changes?
- How might human activities be affecting the temperature of Earth's atmosphere?
- How have human activities affected the ozone layer?

Key Terms

- El Niño • La Niña
- global warming
- greenhouse gas
- chlorofluorocarbon

Target Reading Skill

Asking Questions Before you read, preview the red headings. Ask a *what* or *how* question for each heading, for example, "How does short-term climate change occur?" As you read, write the answers to your questions.



Discover Activity

What Is the Greenhouse Effect?

1. Cut two pieces of black construction paper to fit the bottoms of two shoe boxes.
2. Place a thermometer in each box. Record the temperatures on the thermometers. Cover one box with plastic wrap.
3. Place the boxes together where sunlight or a light bulb can shine on them equally. Make sure the thermometers are shaded by the sides of the boxes.
4. Wait 15 minutes and read the thermometers again. Record the temperatures.



Think It Over

Inferring How can you explain any temperature difference between the two boxes?

If you live in one area for several years, you get to know the area's climate. But in some years, the weather is so unusual that you might think the climate has changed. That's what happened in several different parts of the world during 1997–1998. Droughts occurred in parts of Africa, Asia, and Australia. Heavy rains struck parts of South America. In the United States, very heavy rains swept across California and the South.

What produced these global changes? During the droughts and floods of 1998, parts of the Pacific Ocean were much warmer than usual. Even the ocean's winds and currents changed. Scientists have evidence that these changes in the Pacific Ocean led to wild weather in other parts of the world.

◀ In 1998, mudslides from heavy rains caused severe damage in California.



Discover Activity

Skills Focus Inferring

L1

Materials 2 pieces of black construction paper, 2 shoe boxes, 2 thermometers, plastic wrap, masking tape, source of sunlight or lamp

Time 15 minutes, 5 minutes

Tips Tape the plastic wrap tightly to the box so that the box is airtight. The

thermometers must be shaded. If not, they will give artificially high readings.

Expected Outcome The box covered with plastic wrap will be warmer.

Think It Over Light rays that enter both boxes radiate as heat from the box bottom. Heat is trapped inside the box with plastic wrap; heat escapes from the box without the wrap.

Global Changes in the Atmosphere

Objectives

After this lesson, students will be able to

I.4.4.1 Identify events that can cause short-term climate changes.

I.4.4.2 Describe how human activities might be affecting the temperature of Earth's atmosphere.

I.4.4.3 Explain how human activities have affected the ozone layer.

Target Reading Skill

Asking Questions Explain that changing a heading into a question helps students anticipate the ideas, facts, and events they are about to encounter.

Answers

Possible questions and answers:

What is the greenhouse effect? (*The process by which gases in Earth's atmosphere trap solar energy*) **Why is ozone depletion a concern?** (*A decrease in ozone in the stratosphere causes more ultraviolet light, which is harmful, to reach Earth's surface.*)

All in One Teaching Resources

- [Transparency I47](#)

Preteach

Build Background Knowledge

L2

Global Warming

Invite students to explain what they think of when they hear about global warming and the depletion of the ozone layer. Then elicit their ideas of how the actions of people might affect climate. Record students' remarks on the board. As they study this section, refer to these comments and encourage students to modify the remarks, if necessary.

Instruct

Short-Term Climate Change

Teach Key Concepts

El Niño and La Niña

Focus As a class, brainstorm effects of El Niño and La Niña, such as heavy rains, hurricanes, or landslides.

Teach Explain to students, that during normal years, easterly winds keep a low mound of very warm water in the western Pacific. During El Niño years, these winds weaken and the warm water flows east. During La Niña years, the winds are stronger than normal. Ask: **How could changes in the western Pacific Ocean affect the United States?** (*The ocean and atmosphere are linked. Changes in ocean surface temperature can affect short-term climate over a large region.*)

Apply Ask: **How do scientists know when El Niño or La Niña occurs?** (*They use equipment floating in the ocean and satellites to measure water temperature.*)

Independent Practice

L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: [Global Changes in the Atmosphere](#)

Help Students Read

Relating Cause and Effect Have students list cause-and-effect relationships as they read about global warming and ozone depletion, then compare their lists.

Lab zone Teacher Demo

L1

Bubbles in Ice

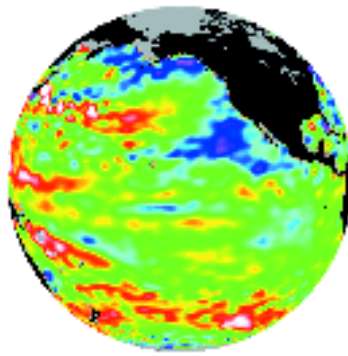
Materials Block of ice

Time 5 minutes

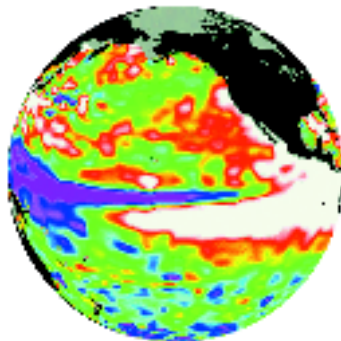
Focus Ask: **Does ice contain anything aside from water?** (*Most students will say no. Tell them that they will learn something about ice.*)

Teach Have students examine a block of ice and look closely for bubbles. Explain that the bubbles are samples of air that were incorporated into the ice when it froze.

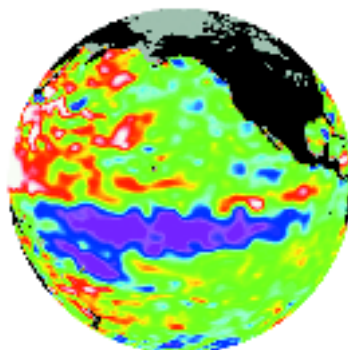
Apply Ask: **What could scientists learn from ice that formed hundreds or thousands of years ago?** (*The composition of the atmosphere at that time*)



▲ In normal years, water in the eastern Pacific is kept relatively cool by currents along the coast of North and South America.



▲ When El Niño occurs, warm surface water from the western Pacific moves east toward the coast of South America.



▲ La Niña occurs when surface waters in the eastern Pacific Ocean are colder than normal.

FIGURE 21

El Niño and La Niña

In these satellite images, warmer water is red and white. Cooler water is blue and purple.

Short-Term Climate Change

Changes in ocean currents and winds can greatly affect climate. **El Niño and La Niña are short-term changes in the tropical Pacific Ocean caused by changes in ocean surface currents and prevailing winds.** El Niño and La Niña both influence weather patterns all over the world.

El Niño The warm-water event known as **El Niño** begins when an unusual pattern of winds forms over the western Pacific. This causes a vast sheet of warm water to move eastward toward the South American coast, as shown in Figure 21. El Niño causes the surface of the ocean in the eastern Pacific to be unusually warm. El Niño typically occurs every two to seven years.

The arrival of El Niño's warm surface water disrupts the cold ocean currents along the western coast of South America and changes weather patterns there. El Niño also affects weather patterns around the world, often bringing severe conditions such as heavy rains or droughts. El Niño conditions can last for one to two years before normal winds and currents return.

La Niña When surface waters in the eastern Pacific are colder than normal, a climate event known as **La Niña** occurs. A La Niña event is the opposite of an El Niño event. La Niña events typically bring colder than normal winters and greater precipitation to the Pacific Northwest and the north central United States. Another major effect of La Niña is greater hurricane activity in the western Atlantic.



How often does El Niño typically occur?

Differentiated Instruction

Less Proficient Readers

L1

Making a Concept Map Ask students to draw a concept map about global warming. Suggest that they look over the section before they read it so they can choose a title and the major concepts for their concept maps. Tell them to look for key words such as *cause* and *result*. You might wish to make photocopies of this section and have students highlight

phrases to insert in their maps. Model how to start the concept map. **learning modality: visual**

Global Warming

Most changes in world climates are caused by natural factors. But recently scientists have observed climate changes that could be the result of human activities. For example, over the last 120 years, the average temperature of the troposphere has risen by about 0.5 Celsius degree. This gradual increase in the temperature of Earth's atmosphere is called **global warming**.

The Greenhouse Hypothesis Recall that gases in Earth's atmosphere hold in heat from the sun, keeping the atmosphere at a comfortable temperature for living things. The process by which gases in Earth's atmosphere trap this energy is called the greenhouse effect. Look at the greenhouse in Figure 22. Notice that sunlight does not heat the air in the greenhouse directly. Instead, sunlight first heats the soil, benches, and pots. Then infrared radiation from these surfaces heats the air in the greenhouse. The greenhouse effect in Earth's atmosphere is similar in some ways.

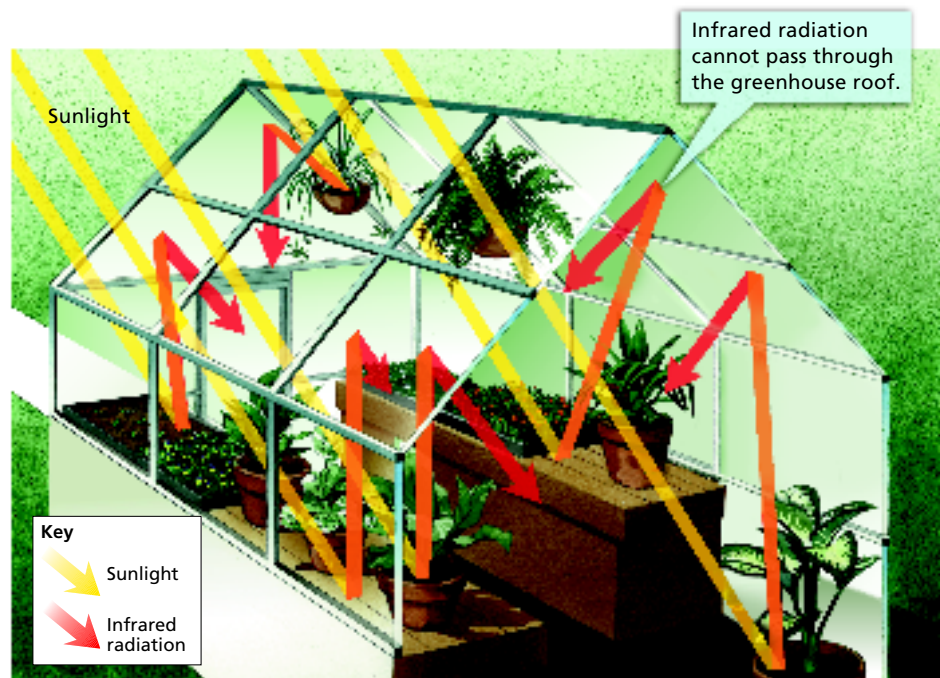
Gases in the atmosphere that trap energy are called **greenhouse gases**. Carbon dioxide, water vapor, and methane are some of the greenhouse gases. **Many scientists have hypothesized that human activities that add greenhouse gases to the atmosphere may be warming Earth's atmosphere.**

FIGURE 22

Greenhouse Effect

Sunlight enters a greenhouse and is absorbed. The interior of the greenhouse radiates back energy in the form of infrared radiation, or heat. Much of the heat is trapped and held inside the greenhouse, warming it.

Applying Concepts What gases in Earth's atmosphere can trap heat like a greenhouse?



Global Warming

Teach Key Concepts

L2

Human Activities and Global Warming

Focus Make a list with students of common greenhouse gases. (*Water vapor, carbon dioxide, methane, nitrous oxide*)

Teach Ask: **Where does most of the heat on Earth come from?** (*the Sun*) **What happens when sunlight hits Earth's surface?** (*Earth's surface warms.*) **And how does this affect the atmosphere?** (*Earth's surface emits infrared radiation that warms the lower atmosphere*)

Tell students that greenhouse gases hold more of this heat in Earth's atmosphere than normally would be held. Ask: **What might happen if levels of greenhouse gases increase?** (*Earth's atmosphere will hold more heat and become warmer.*)

Apply Ask students to predict possible effects of global warming. (*Possible answers: Areas that are now warm might become too arid to farm; cool areas might produce more crops; very low coastal areas might be under water.*) **learning modality: visual**

All in One Teaching Resources

- [Transparency I48](#)

Monitor Progress

L2

Drawing Challenge students to draw diagrams showing how greenhouse gases trap heat energy from sunlight in Earth's atmosphere.

Answers

Figure 22 Carbon dioxide, water vapor, and methane, among others



every two to seven years

Use Visuals: Figure 23

Changing Levels of Carbon Dioxide

Focus Direct students to the graph in the figure. Have them identify the graph title and explain what is shown on each axis.

Teach Ask: **Describe how the level of carbon dioxide changed from the year 1000 to 1800.** (*There were small fluctuations, but it stayed about the same*) **What happened after 1800?** (*The carbon dioxide level increased significantly.*)

Apply Ask: **Why do you think carbon dioxide levels started to increase around 1800?** (*A possible answer is that this is the time when the Industrial Revolution began and people started to burn large amounts of fossil fuels.*)

Integrate Environmental Science

Because of the increase of carbon dioxide in the atmosphere, many ideas have been suggested about how to sequester, or store away, carbon dioxide. These ideas range from adding iron to parts of the ocean to increase plankton growth to capturing carbon dioxide emissions from smoke stacks. Because worldwide release of carbon dioxide is projected to increase, such strategies might become an important way to reduce the impact of burning fossil fuels.

Changing Levels of Carbon Dioxide Scientists think that an increase in carbon dioxide is a major factor in global warming. Until the late 1800s, the level of carbon dioxide in the atmosphere remained about the same. How did scientists determine this? They measured the amount of carbon dioxide in air bubbles trapped in Antarctic ice. They obtained these samples of ancient air from ice cores, as shown in Figure 23. The glacier that covers Antarctica formed over millions of years. Gas bubbles in the ice cores provide samples of air from the time the ice formed.

Is global warming caused by human activities, or does it have a natural cause? Scientists have done a great deal of research to try to answer this question.

Since the late 1800s, the level of carbon dioxide in the atmosphere has increased steadily, as shown in Figure 23. Many scientists think that this change is a result of increased human activities. For example, the burning of wood, coal, oil, and natural gas adds carbon dioxide to the air. During the last 100 years, these activities have increased greatly in many different countries. Some scientists predict that the level of carbon dioxide could double by the year 2100. If that happens, then global temperature could rise by 1.5 to 3.5 Celsius degrees.

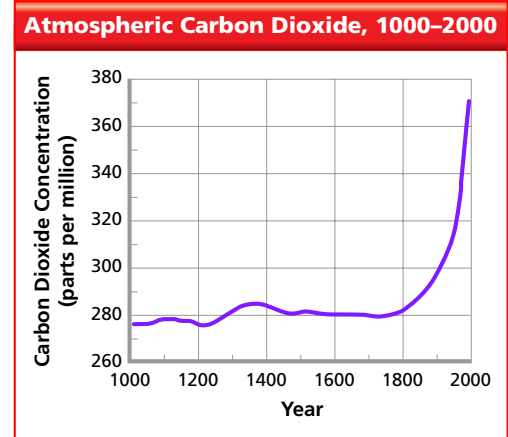


FIGURE 23

Carbon Dioxide Levels

These scientists are taking an ice core from the glacier that covers Antarctica (left). Gas bubbles in the ice provide samples of the atmosphere at the time the ice formed. Data from ice cores enables scientists to graph changing levels of carbon dioxide (above).



1960



1990

FIGURE 24

Melting Glaciers

The photos show the Burroughs glacier in Alaska. The photo on the left was taken in 1960. The photo on the right was taken in 1990, and shows the large amount of melting that has taken place.

Climate Variation Hypothesis Not all scientists agree about the causes of global warming. Some scientists think that the 0.5 Celsius degree rise in global temperatures over the past 120 years may be part of natural variations in climate rather than a result of increases in carbon dioxide.

Satellite measurements have shown that the amount of energy the sun produces increases and decreases from year to year. These changes in solar energy could be causing periods of warmer and cooler climates. Or climate change could be a result of changes in both carbon dioxide levels and the amount of solar energy.

Possible Effects Global warming could have some positive effects. Farmers in some cool areas could plant two crops a year. Places that are too cold for farming today could become farmland. However, many effects of global warming are likely to be less positive. Higher temperatures would cause water to evaporate from exposed soil, such as plowed farmland. Dry soil blows away easily. Thus, some fertile fields might become “dust bowls.”

A rise in temperatures of even a few degrees could warm up water in the oceans. Some scientists think warmer ocean water could increase the strength of hurricanes.

As the water warmed, it would expand, raising sea level around the world. The melting of glaciers and polar ice caps could also increase sea level. Sea level has already risen by 10 to 20 centimeters over the last 100 years, and could rise another 25 to 80 centimeters by the year 2100. Even such a small rise in sea level would flood low-lying coastal areas.



What are three possible effects of global warming?

Go online
PLANET DIARY

For: More on the greenhouse effect
Visit: PHSchool.com
Web Code: cfd-4044

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PLANET DIARY

For: More on the
greenhouse effect
Visit: PHSchool.com
Web Code: cfd-4044

Download a worksheet that will guide students' review of Internet resources on global warming.



Build Inquiry

Comparing Rates of Evaporation

L2

Materials 2 beakers, hot plate, water

Time several hours

Focus Remind students that when water evaporates it changes into a gas and enters the atmosphere.

Teach Have students carefully pour the same amount of tap water into two beakers. Students should mark the level of water in each. Tell students to place one beaker on a laboratory table. They should place the other beaker on a hot plate. Have them turn the hot plate to a temperature that is higher than room temperature but well below the boiling point of water. Students should periodically observe the level of water in each beaker.

CAUTION: Make certain that students wear protective mitts. Supervise their use of the hot plate.

Apply Ask: How did higher temperature affect the rate of evaporation? (It increased it.) If temperatures on Earth rise, how would this affect the amount of water evaporated from soil? (It would increase the amount of water evaporated.)

Monitor Progress

L1

Skills Check Have students explain how global warming can affect the size of a glacier.



Possible answer: Rising sea levels, stronger hurricanes, melting glaciers

Ozone Depletion

Teach Key Concepts

L2

Human Activities and the Ozone Layer

Focus Remind students that ozone is a molecule made up of three atoms of oxygen. You might want to draw a simple diagram on the board.

Teach Tell students that chlorine from CFCs can break apart ozone molecules to form an oxygen molecule and a single atom of oxygen. The single atoms of oxygen combine to form more oxygen molecules. Ask: **What might happen if ozone levels decrease?**

(More ultraviolet radiation from the sun will reach Earth's surface.) **What effects could this have?** (More people might get skin cancer or eye damage.)

Apply Ask: **How can you protect yourself from ultraviolet radiation?** (Avoid exposure to midday sun, wear hats and long sleeves, apply sunscreen) **learning modality: logical/mathematical**

All in One Teaching Resources

- [Transparency I49](#)

Address Misconceptions

L2

Ozone in Smog

Focus Ask: **If ozone is important, why are ozone warnings sometimes issued?** (Accept all responses as a basis for discussion.)

Teach Explain that ozone is the major compound in smog. It typically forms when emissions from gasoline engines react in the presence of sunlight. Ozone can irritate the respiratory system and eyes, and can damage plants. Tell students that ozone that forms low in the atmosphere can be damaging. However, ozone in the stratosphere blocks ultraviolet radiation and is helpful to life on Earth.

Apply Ask: **What precautions should you take during an ozone advisory?** (Avoid strenuous exercise, remain inside buildings on hot days) **learning modality: logical/mathematical**

Lab zone Try This Activity

It's Your Skin!

Compare how well sunscreens block out ultraviolet rays.

1. Close the blinds or curtains in the room. Place one square of sun-sensitive paper inside each of three plastic sandwich bags.
2. Place three drops of one sunscreen on the outside of one bag. Spread the sunscreen as evenly as possible. Label this bag with the SPF number of the sunscreen.
3. On another bag, repeat Step 2 using a sunscreen with a different SPF. Wash your hands after spreading the sunscreen. Leave the third bag untreated as a control.
4. Place the bags outside in direct sunlight. Bring them back inside after 3 minutes or after one of the squares turns completely white.

Drawing Conclusions Did both of the sunscreens block ultraviolet radiation? Was one better than the other? Explain.

Ozone Depletion

Another global change in the atmosphere involves the ozone layer. Ozone in the stratosphere filters out much of the harmful ultraviolet radiation from the sun, as shown in Figure 25.

In the 1970s, scientists noticed that the ozone layer over Antarctica was growing thinner each spring. A large area of reduced ozone, or ozone hole, was being created. In 2000, the ozone hole reached a record size of over 28.5 million km²—almost the size of Africa. Satellite data indicates that the ozone hole in 2003 was nearly as large as it was in 2000. What created the ozone hole? **Chemicals produced by humans have been damaging the ozone layer.**

Chlorofluorocarbons A major cause of ozone depletion is a group of compounds called **chlorofluorocarbons**, or CFCs. CFCs were used in air conditioners and refrigerators, as cleaners for electronic parts, and in aerosol sprays, such as deodorants.

Most chemical compounds released into the air eventually break down. CFCs, however, can last for decades and rise all the way to the stratosphere. In the stratosphere, ultraviolet radiation breaks down the CFC molecules into atoms, including chlorine. The chlorine atoms then break ozone down into oxygen atoms.

Results of Ozone Depletion Because ozone blocks ultraviolet radiation, a decrease in ozone means an increase in the amount of ultraviolet radiation that reaches Earth's surface. Ultraviolet radiation can cause eye damage and several kinds of skin cancer.

In the late 1970s, the United States and many other countries banned most uses of CFCs in aerosol sprays. In 1990, many nations agreed to phase out the production and use of CFCs. Because ozone depletion affects the whole world, such agreements must be international to be effective. Worldwide production of the chemicals has greatly decreased. In the United States, at the current rate it will take until 2010 to completely eliminate the use of CFCs.



What are CFCs?

Lab zone Try This Activity

Skills Focus Drawing conclusions **L2**
Materials ultraviolet-sensitive paper, 3 plastic sandwich bags, 2 sunscreens with different SPF numbers, black marking pen

Time 15 minutes

Tips Use sunscreens with widely different SPF numbers. Obtain UV-sensitive paper from toy or craft stores (called "Sunprint Kit"). Precut the paper to save class time.

Expected Outcome The paper without sunscreen shows the most color change, and the paper covered with the highest SPF sunscreen shows the least.

Extend Encourage students to return the bags with sunscreen to direct sunlight and monitor them to find out how long the sunscreen is effective. **learning modality: kinesthetic**

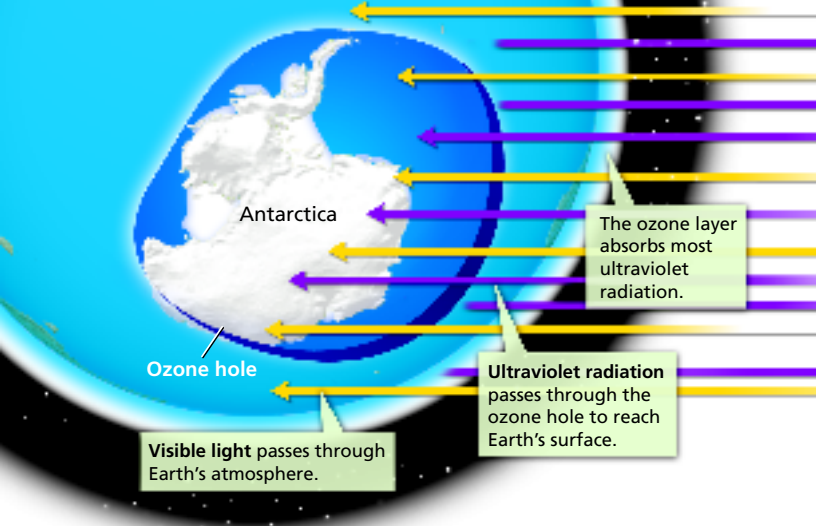
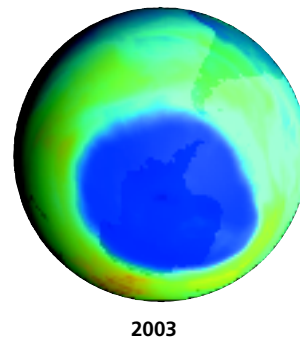
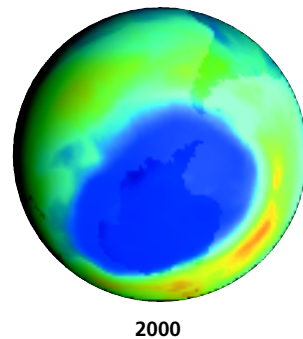
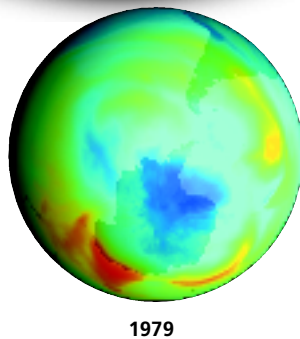


FIGURE 25
The Ozone Hole

The ozone layer blocks much of the ultraviolet radiation (purple) coming from the sun. Visible light (yellow) can pass through the ozone layer. The satellite images below show the concentration of ozone over the South Pole for three years. The dark area shows where the ozone layer is thinnest. **Observing** How has the size of the ozone layer changed over time?



Section 4 Assessment

Target Reading Skill

Asking Questions Use the answers to your *what* and *how* questions to help you answer the questions below.

Reviewing Key Concepts

- Listing** What are two events that can cause short-term climate change?
 - Describing** Describe the changes that occur in the Pacific Ocean and the atmosphere above it during El Niño.
 - Relating Cause and Effect** What effects does El Niño have on weather and climate?
- Defining** What is global warming?
 - Relating Cause and Effect** How do scientists think that increased carbon dioxide levels contributed to global warming?

- Reviewing** What effect have human activities had on the ozone layer?
 - Summarizing** Summarize the cause of ozone depletion and the steps taken to reverse it.

Lab zone

At-Home Activity

Sun Protection Visit a drugstore with your family. Compare the SPF (sun protection factor) of the various sunscreens for sale. Explain why it is important to protect your skin from ultraviolet radiation. Ask your family members to determine the best value for the money in terms of SPF rating and price.

Lab zone

At-Home Activity

Sun Protection **L1** Have students practice explaining the importance of protecting skin from ultraviolet radiation and the meaning of SPF. Inform students that dermatologists recommend a sunscreen with an SPF of at least 30.

Monitor Progress L2

Answers

Figure 25 The “hole” in the ozone layer grew larger until about 2000. Some research suggests that the controls on CFC production will prevent the ozone hole from getting any larger.



A group of chlorine compounds formerly used in airconditioners and refrigerators, as cleaners for electronic parts, and in spray cans. The compounds last for decades and break down the ozone layer.

Assess

Reviewing Key Concepts

- El Niño and La Niña
 - Winds that normally would keep warm water in the western Pacific weaken and warm water flows back to the eastern Pacific. This triggers further changes in the atmosphere.
 - Some regions may have heavy rains while other regions may have droughts.
- A gradual increase in the temperature of Earth’s atmosphere
 - Carbon dioxide is a greenhouse gas. Increasing the amount of carbon dioxide in the atmosphere causes Earth’s atmosphere to hold more heat.
- The release of CFCs into the atmosphere reduced the amount of ozone in the ozone layer.
 - Ozone depletion occurred as a result of the release of CFCs into the atmosphere. Under international treaties, production and use of CFCs is now being phased out.

Reteach L1

Summarize the factors that may be causing global warming and factors that are causing ozone depletion in the atmosphere.

Performance Assessment L2

Writing Have students write a pamphlet or a letter to the editor informing the public about what causes global warming and the depletion of the ozone layer, and what they can do about it.

All in One Teaching Resources

- [Section Summary: Global Changes in the Atmosphere](#)
- [Review and Reinforce: Global Changes in the Atmosphere](#)
- [Enrich: Global Changes in the Atmosphere](#)